AL-802618-69-

13 May 1969

Dear Dave:

25X1 Subject: Contract [redacted] Proposal for PAR 252 - "Improvement of the Precision Enlarger Fluid Injection System".

Reference: Our message 2396 (Corrected Copy), dated 9 May 1969.

In accordance with the referenced message we are submitting the subject proposal herewith, at a total CPFF cost of [redacted], including 25X1
25X1 [redacted] fixed fee, consisting of PAR description, schedule and estimated cost breakdown.

25X1

[redacted]

R. R. W.

RRW:sjm
Encs.

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2: RS w/encs. (AL-700513-69-002 thru 006 & AL-402221-69-002)

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PAR 252

Improvement of Precision Enlarger Fluid Injection System

28 April 1969

PROJECT AUTHORIZATION REQUEST

PAR 252
28 Apr 69

SUBJECT: Improvement of the Precision Enlarger Fluid Injection System

TASK/PROBLEM

1. Develop, fabricate, test, and evaluate an improved fluid-injection-system breadboard that will be compatible with the fluid-gate requirements of both the STAT [redacted] Precision Enlarger (BPE) and 10-20-40X Precision Enlargers.

PROPOSAL

2. Introduction. During the past few years, Precision Enlargers used in the field have experienced certain failures in the system used to inject refractive index matching fluid into the negative gate. These failures prompted the search for an improved system. As a result, a wide variety of fluid moving methods were considered as well as the problem of controlling the fluid volume delivered. Two objectives were: (1) to obtain a system that would be highly resistant to the chemical properties of commonly used fluids of the chlorinated hydrocarbon type, and (2) to provide rapid efficient delivery of fluid to the point of application.

3. Establishment of Design Goals. An ideal fluid injection system should have the following characteristics and capabilities:

a. Relatively inexpensive to manufacture.

b. Reliable and mechanically simple.

c. Highly resistant to chemical attack by the fluid.

d. Simple to operate.

e. Adaptable to both the BPE and to the 10-20-40X Precision Enlargers.

f. Safe for operators to use.

g. Adjustable delivery volume.

h. Readily visible fluid supply level.

4. General Approach:

a. Of the methods that were considered for moving the fluid, a simple centrifugal pump appears to be the most desirable. Because such pumps contain no precision parts, they are economical to manufacture; in addition, lack of precision parts makes it possible to choose from a wider range of fabrication materials. As a result, the task of finding a pump material that resists chlorinated hydrocarbons is made easier.

b. Immersion of the pump in the fluid supply will render it self-priming. The use of a long shaft will keep the motor out of the fluid reservoir and eliminate the need for potentially troublesome seals. Electrical control of such a pump is relatively simple, and it can be fitted within a transparent or translucent reservoir, thus providing ready visibility of the fluid level. A schematic diagram of such a system is shown in Figure 1.

c. It is proposed that the volume of fluid delivered be metered by controlling the operating time of the pump. This can be accomplished electrically by such a device as the variable-time-delay relay. This approach is preferred because of its simplicity. It eliminates use of valves and permits the fluid lines and nozzles to drain back through the pump into the reservoir as does the present system. However, the possibility that valves might be desirable in the future was considered, and if suitable hardware is developed and offers advantages, this approach could be pursued.

5. Testing. To make testing and evaluation of the fluid injection system breadboard as meaningful as possible, it is planned to operate the pump for an extended period of time and to schedule complete operating cycles for the equipment. By setting the system up as a closed loop, a hundred or more cycles per hour on a 24-hour test schedule should be possible. This effort will determine the reliability of the design and its resistance to attack by the refractive index fluid.

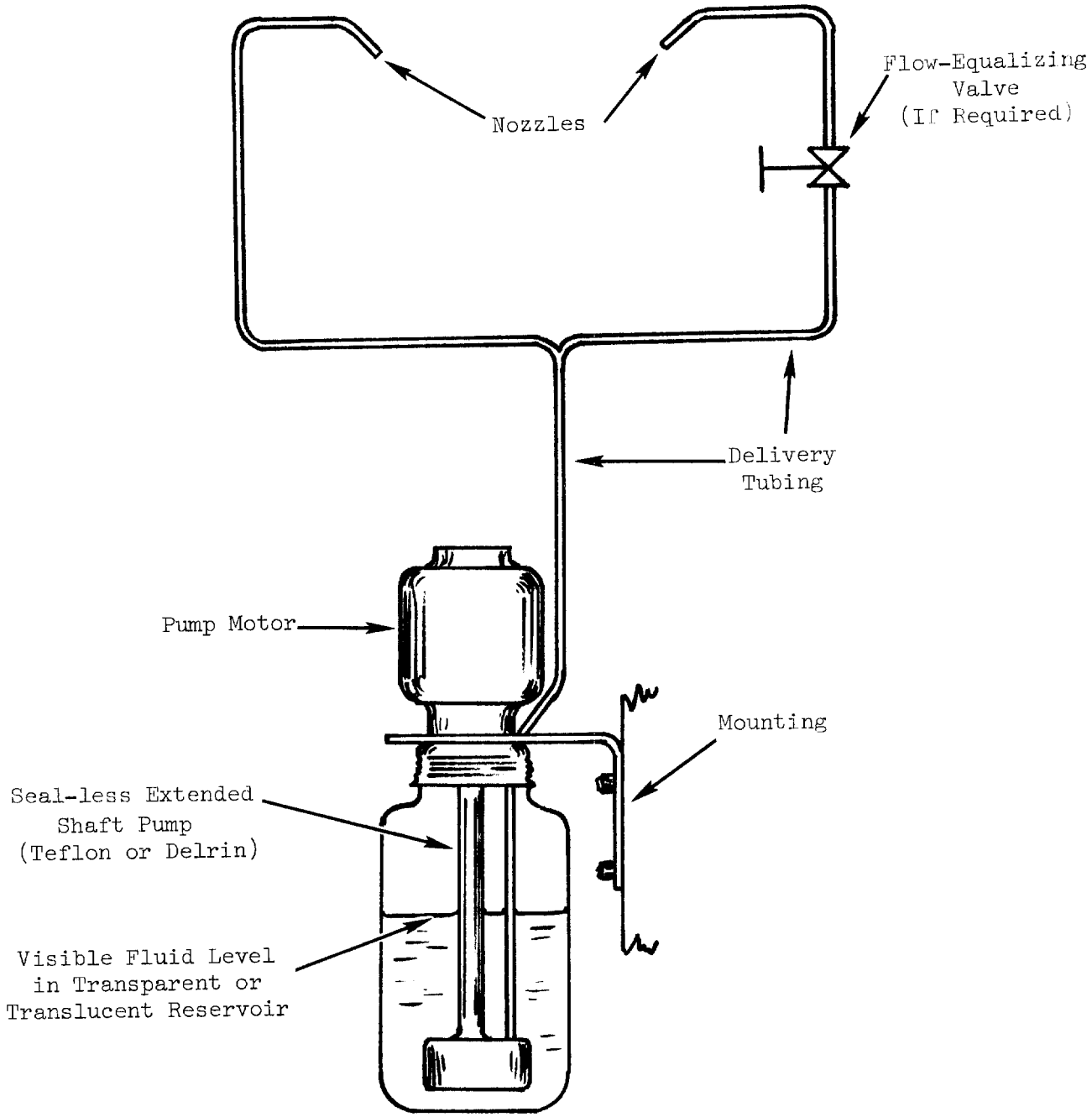

Figure 1. Proposed Centrifugal Pump System

PROGRAM OBJECTIVE

6. Develop a refractive-index fluid-injection system for use with the [redacted] and 10-20-40X Precision Enlargers that will prove more reliable, more economical to manufacture, and less subject to attack by the hydrocarbon fluids now used in these systems. 25X1

7. If the system proves to be successful, it can then be incorporated in present and future designs of printers requiring liquid gates. At the time of its first production lot, kits could be made for retrofitting printers already in the field.

SCHEDULE

8. A tentative schedule covering the major phases of effort is shown in Figure 2. Changes in this schedule that may be necessary as the work progresses will be reviewed with the customer.

TENTATIVE SCHEDULE

Improvement of the Precision Enlarger
Fluid Injection System

PAR 252
28 Apr 69

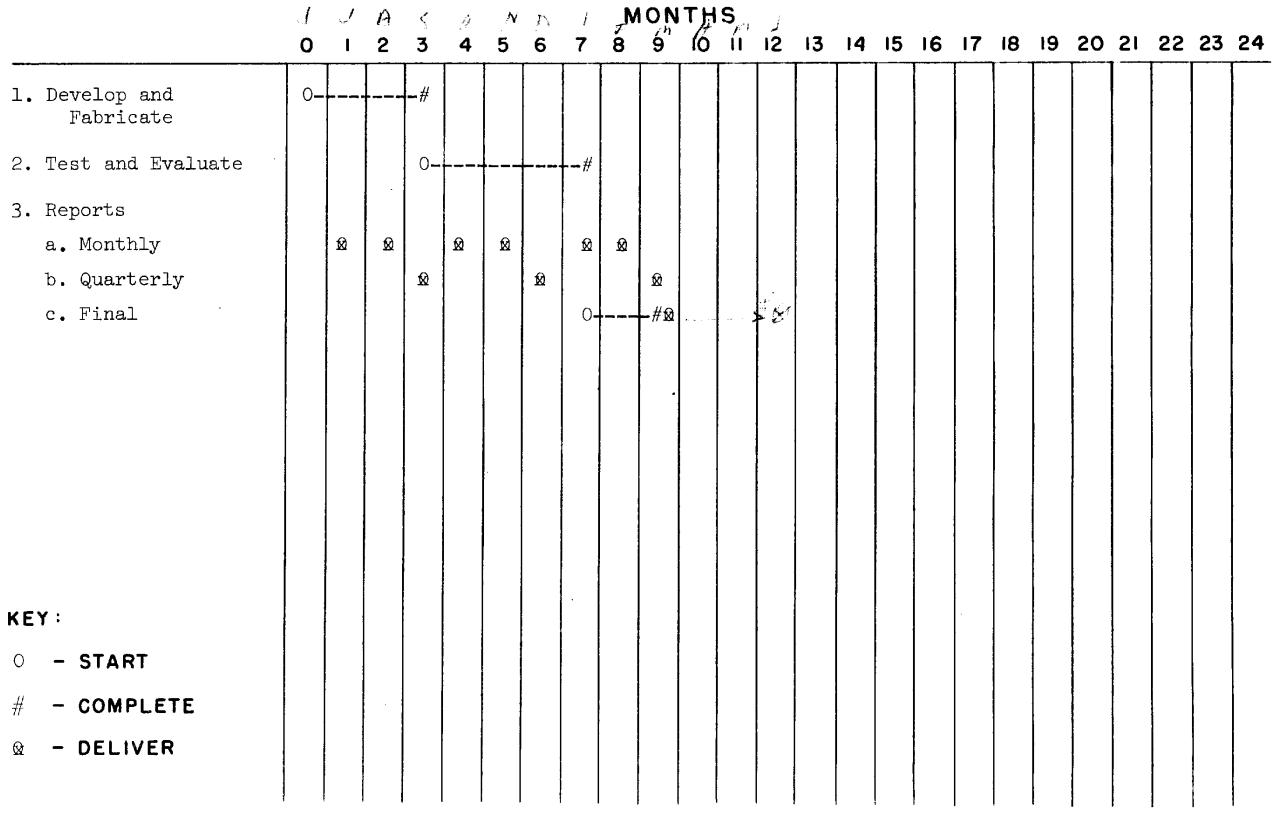

Figure 2

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PAR 252

FINAL REPORT

Improvement of the Precision Enlarger Fluid Injection System

11 June 1970

Prepared by:

[redacted] 25X1

Approved by:

25X1 [redacted]

Date: 15 June 1970

Contract [redacted] 25X1

PAR 252
11 June 70

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SUMMARY

Problems experienced with fluid injection pumps on Precision Enlargers in the field prompted the development of a new, improved pump for precision enlargers. These problems concerned (1) the system's capability to inject refractive index matching fluid into the negative gate, and (2) rust corrosion.

The improved fluid injection pump has the following desirable features:

1. It is made of Delrin, a plastic that is solvent proof, acid proof, and eliminates all rust problems.

2. One new pump will handle the needs of a precision enlarger that requires two of the existing pumps.

3. The newly developed pump is of the centrifugal type as opposed to the present piston type. As a result, it provides a constant flow of index matching fluid into the gate while the operator is closing it.

4. The new pump is both compact and simple: The total number of parts required is about one-fourth that of existing pumps.

5. The quantity of fluid delivered is regulated by means of adjustable valves and a variable time-delay relay that controls the duration of pump operation.

6. A slow-blowing fuse in the motor circuit protects the motor from the possibility of burnout.

Because of the demonstrated advantages of this improved pump, it should be considered for use in all new Precision Enlargers and BPE's. Consideration should also be given to supplying retrofit kits to customers who are experiencing difficulty or unusual maintenance requirements on existing equipment.

PAR 252
11 June 70

SUBJECT: Improvement of the Precision Enlarger Fluid Injection System

TASK/PROBLEM

1. Develop, fabricate, test, and evaluate an improved fluid-injection-system breadboard that will be compatible with the fluid gate requirements of both the [redacted] Precision Enlarger (BPE) and 10-20-40X Precision Enlargers.

INTRODUCTION

2. Background:

a. It has proven very advantageous over the past few years to employ the fluid-gate principle in Precision Enlargers. The use of a wetting liquid whose index of refraction is a close match to both the glass gate and the film emulsion serves several purposes in a projection printer employing a highly specular light source. Newton's Rings are eliminated, the effects of emulsion surface scratches are eliminated or greatly reduced, foreign particles are flushed from both the glass and film surfaces, and there is a modest increase in light transmittance through the gate sandwich.

b. An index-matching or "immersion" fluid must possess certain properties beyond the obvious requirement for good refractive-index match. It must have a vapor pressure at ambient temperatures which will permit reasonably rapid removal of the liquid from the film through evaporation. On the other hand, the vapor pressure should be low enough so that it will remain liquid in the gate for the time required. It must also be a substance whose absorption by the emulsion is so slight as to be negligible, and it must of course be chemically tolerated by both the emulsion and the film base. Of the few known liquids possessing

the required properties, all are members of the chlorinated-hydrocarbon family and possess other properties which make them somewhat difficult to pump or handle. Precision Enlargers in the field have experienced certain failures and problems with corrosion in the systems used to pump these fluids to the negative gate. These problems have prompted the search for an improved pumping system. As a result, a wide variety of fluid-moving methods were considered as well as the problem of controlling the volume of fluid delivered. Two primary objectives in this effort were: (1) To obtain a system that would be highly resistant to the chemical properties of commonly used refractive index matching fluids, and, (2) to provide rapid, efficient delivery of fluid to the point of application.

3. It was determined that an ideal fluid-injection system should have certain characteristics. These characteristics, which are listed below, were adopted as design goals:

a. Relatively inexpensive to manufacture.
b. Reliable and mechanically simple.
c. Highly resistant to chemical attack by the fluid.
d. Simple to operate.
e. Adaptable to both the BPE and to the 10-20-40X Precision Enlargers.
f. Safe for operators to use.
g. Adjustable delivery volume.
h. Readily visible fluid supply level.

4. The results of testing indicate that the design goals for this PAR were met.

DISCUSSION

5. General:

a. To obtain a pump for the system, consideration was given first to buying a suitable off-the-shelf item. The requirements for this pump were:

(1) Suitability of the material (to withstand index matching fluid and resist corrosion)

(2) Size (complete package to fit in available space on the BPE)

(3) Flow rate and head (adequate for BPE requirements)

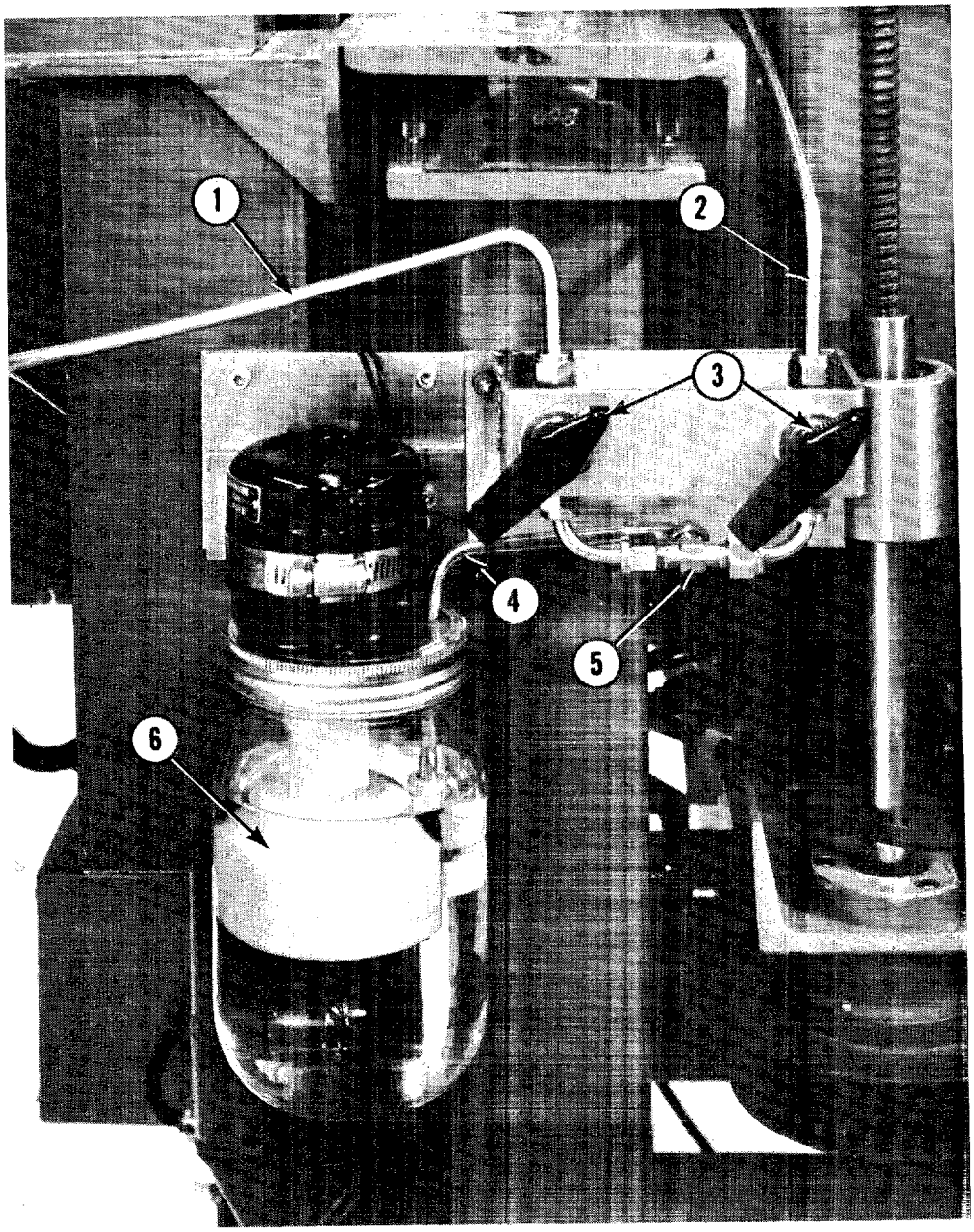
b. The first two requirements eliminated all available off-the-shelf pumps, and pumps that were made of Delrin were too large for our use. The possibility of having a standard pump of suitable size custom molded from Delrin was also explored and rejected because of cost. It was therefore decided to purchase a block of Delrin from which the pump was machined.

c. The fluid injection pump that was developed, fabricated, and tested is shown in Figure 1. It is of the centrifugal type and is small enough to be inserted into a one-quart jar that serves as the fluid reservoir. The output line from the pump is split by means of a T-fitting, and each branch is connected to the fluid lines that were previously connected to the solenoid-operated pumps (see Figure 2).

d. A single pump has the head and flow rate capability to replace both of the pumps previously used on the BPE.

6. Design Configuration and Description:

a. A centrifugal-type pump was considered first as this is the commonest and simplest type of pump. Preliminary calculations showed that the required head and flow rate could probably be met in a fairly small pump.



1. Tube to Lamphouse Side of Gate
2. Tube to Lens Side of Gate
3. Valve Handles for Adjusting Flow
4. Outlet Tube
5. T-Fitting
6. Pump Assembly

Figure 1. Fluid Injection System Installed on Breadboard BPE

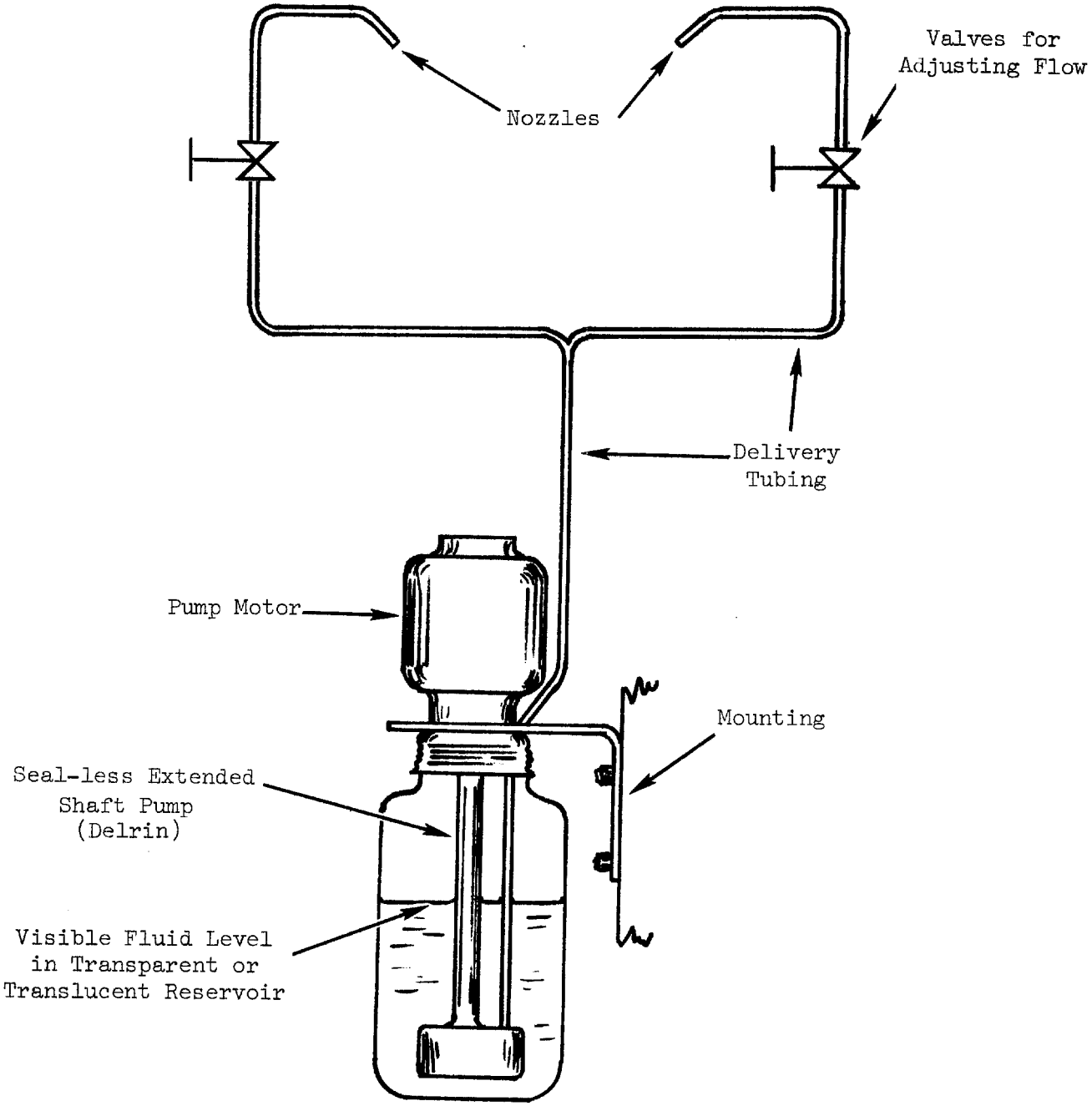


Figure 2. Schematic of Fluid Injection System

b. In the design of the pump, principal consideration was given to simplicity. As a result, the pump consists of four parts, only two of which move (the impellor and the coupling). The parts are shown in Figure 3. They consist of the motor, reservoir cover, body, coupling, impellor, and inlet.

c. A ball valve installed in each branch of the output line helps control the flow. A further aid to controlling the pump flow is the adjustable time-delay relay which regulates the duration of pump operation. This relay is mounted near the other electronic parts and assemblies on the breadboard BPE (see Figure 4). The slow-blowing fuse holder (which uses an indicator light to signal a blown fuse) is also shown in this figure.

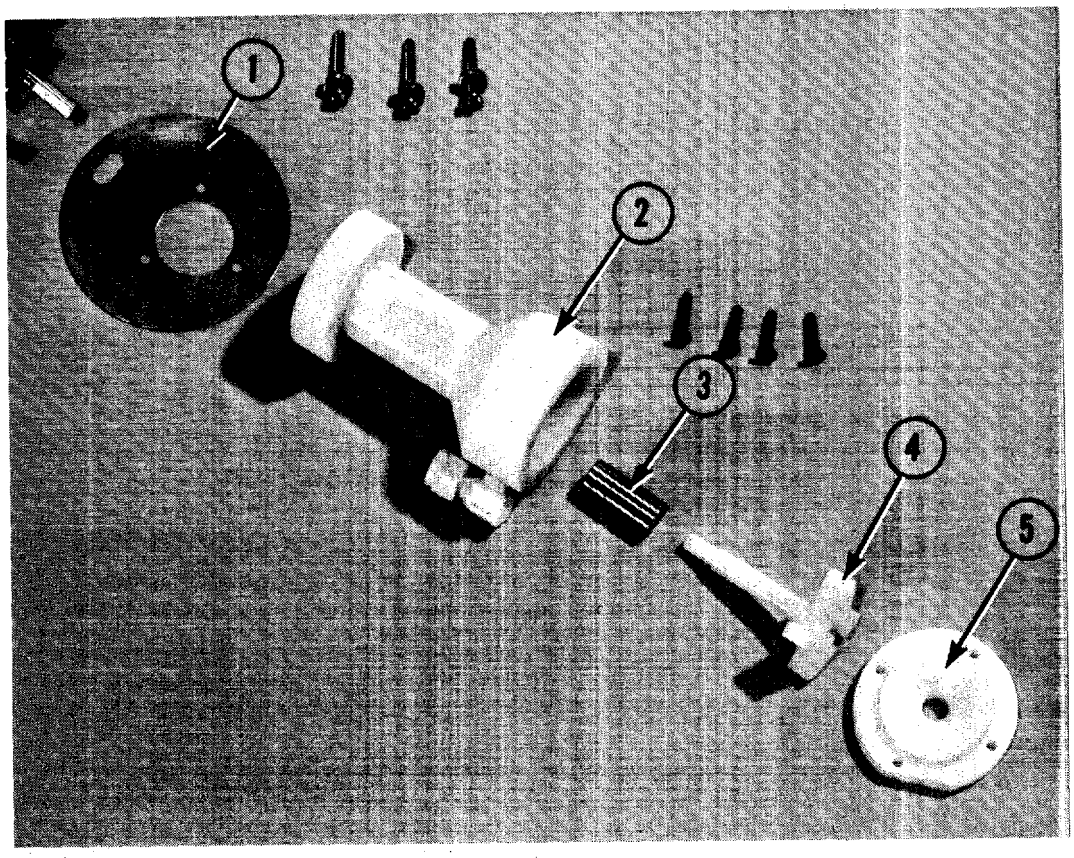
7. Material Choice:

a. Choosing a material that would not rust or corrode and which could resist the solvent properties of the index matching fluid was crucial to a successful pump design. Samples of index matching fluid taken from the supply stocks of certain customers were tested for acidity. Some showed acidity of over one hundred parts per million. As a result, the requirement that the chosen material resist dilute acids was also added.

b. The contractor's chemical services group recommended that Delrin be used for the pump material. An informal test of various plastic materials in index matching fluid affirmed this choice because Delrin was the least affected of the plastics used in the test.

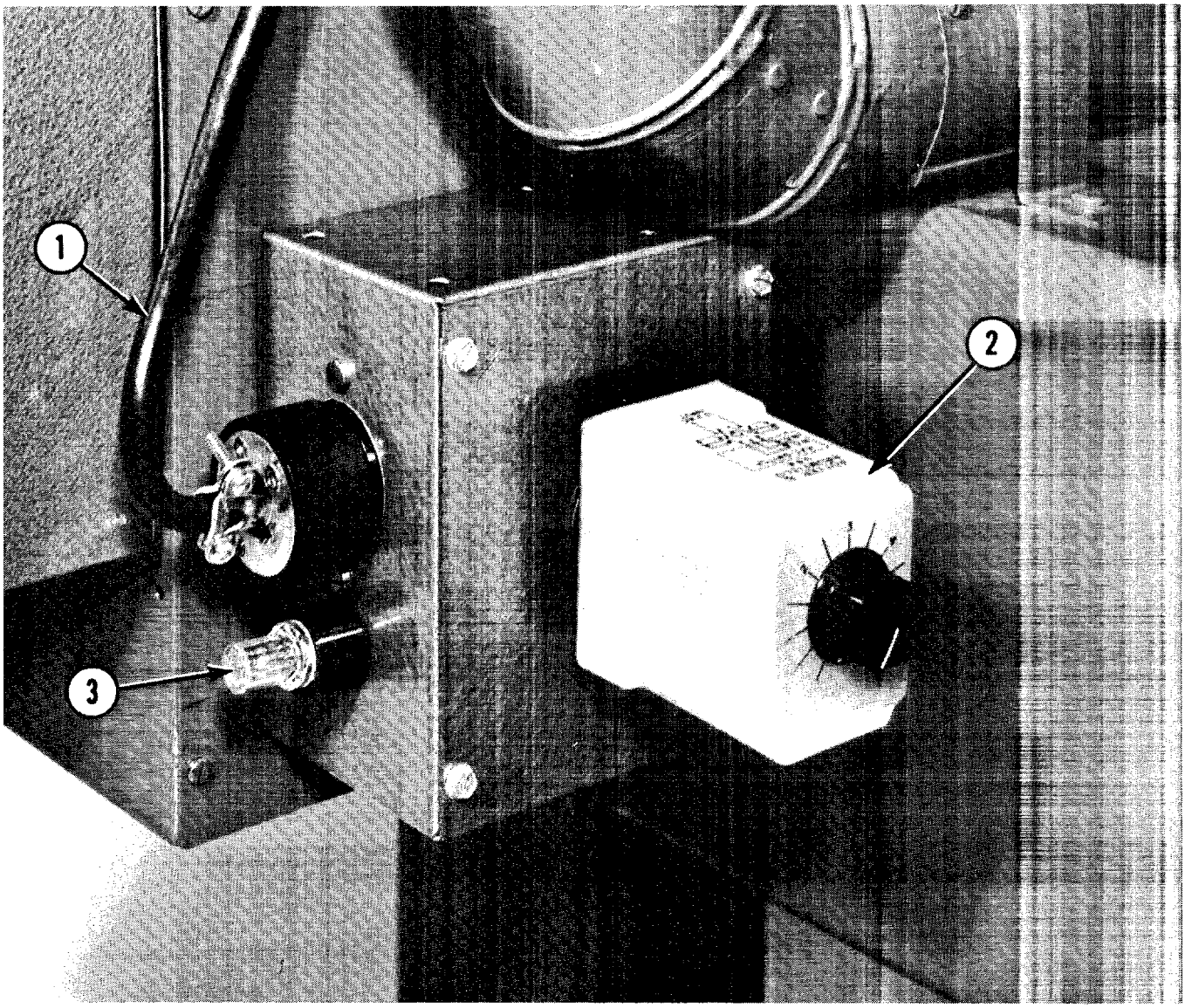
c. A further test of Delrin's qualities occurred when the pump was tested using index matching fluid to which hydrochloric acid has been added in a concentration of 203 parts per million. After two months of operation in this fluid, no adverse effects on the pump could be observed.

8. Problems Encountered During Checkout and Methods Used to Solve Them. The test setup was accidentally left connected over a weekend and the test cycling timer began to operate the pump when there was no fluid in the jar. Since the fluid provides some lubrication and cooling, the



1. Reservoir Cover
2. Body
3. Coupling
4. Impellor
5. Inlet

Figure 3. Pump Disassembled to Show Parts



1. Pump Power Cord
2. Time Delay Relay
3. Fuse Holder

Figure 4. System Electrical Components

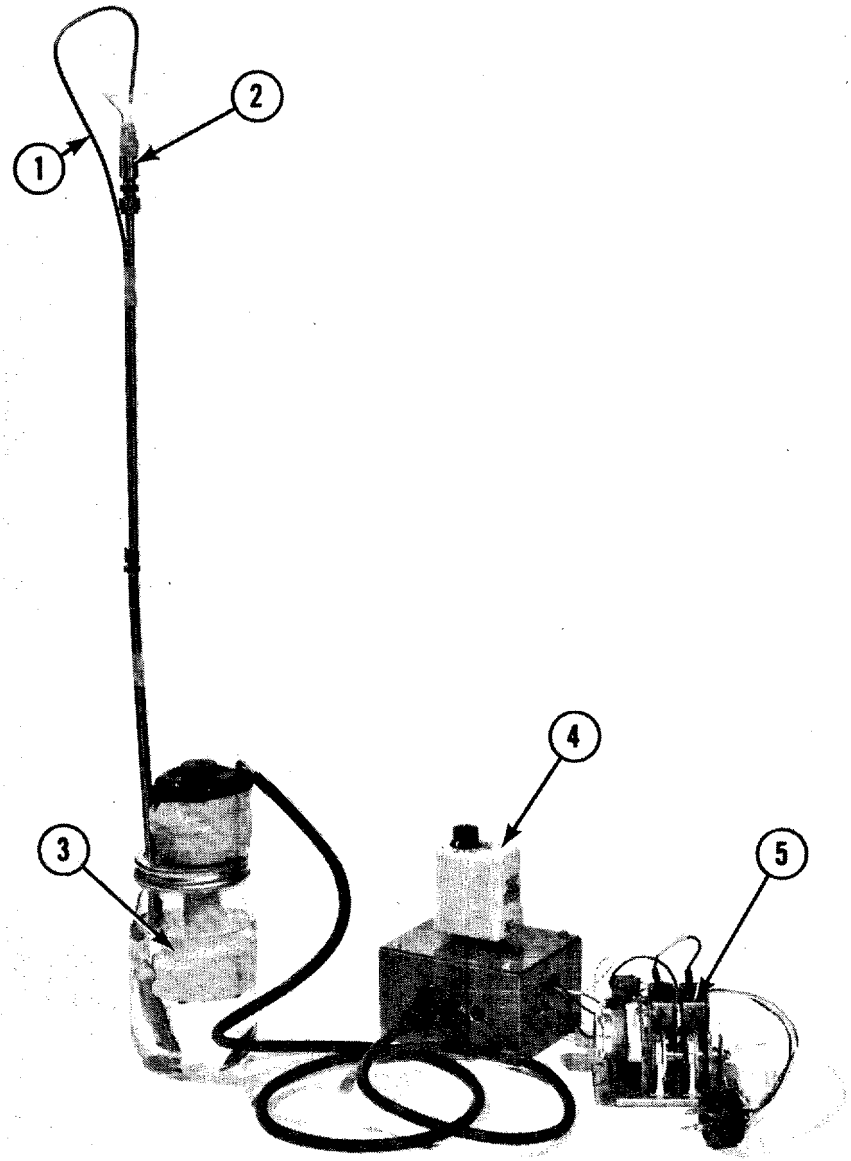
pump eventually seized and the motor burned out. To prevent a recurrence, a 0.3 amp slow-blowing fuse was installed in the motor circuit. This fuse is sufficient for normal operation, but will blow after about ten seconds operation with a locked rotor.

9. Testing and Evaluation:

a. The pump was tested in a set-up that simulated the head and flow rate that a pump would "see" when installed on a BPE. A cycling timer in the pump power circuit was used to turn the pump on for five seconds, every 15 seconds. This test setup is shown in Figure 5.

b. The pump completed approximately 130,000 cycles of operation in testing with this setup. Half of the cycles were completed using acidic index matching fluid. Testing was without incident except for the accident referred to in paragraph 8. The seizure of the pump resulting from this accident was repaired, however, by simply breaking loose the seized impellor, working it free, and flaking off the galled material. No tools were used and the scored surfaces were not smoothed. No change in the performance of the pump could be observed when testing was resumed in spite of the crude nature of this repair. No further problems were encountered.

c. Because the pump performance easily matched BPE needs, absolute flow rate and head measurements were not made.



1. Pump Outlet Tube
2. Drain Back Line
3. Pump Assembly
4. Time Delay Relay
5. Interval Timer

Figure 5. Setup Used for Testing Pump

CONCLUSIONS

10. The improved fluid injection pump met development goals in all respects. The pump easily exceeds the flow rate and head required for the BPE. Because the pump is made of Delrin it can withstand long exposure to index matching fluid, and rust problems are eliminated.

RECOMMENDATIONS

11. It is recommended that existing breadboard sketches be upgraded to prototype design drawings.

12. It is recommended that this pump be considered for use in all new liquid-gate printers such as the 10-20-40X Precision Enlarger and the 25X1 Precision Enlarger.

13. It is further recommended that consideration be given to a retrofit kit for customers who are dissatisfied with the present dual-pump setup and want the advantages of the new pump design.